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14. ABSTRACT

The goal of this project is to identify processes relevant to the finite-amplitude, internal solitary waves observed in the region from the Luzon Strait to the Chinese continental shelf in support of ONR's Nonlinear Internal Waves Initiative (NLIWI). A nonhydrostatic numerical model was adapted to study these waves. Wave generation by a ridge, propagation in the deep basin, and reflection and diffraction by an island were successfully simulated by the numerical model. Parametric dependence of wave characteristics on stratification, ridge height, and bottom topography was studied.

15. SUBJECT TERMS

Internal solitary waves, Luzon Strait, Dungsha Island

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Nonhydrostatic Numerical Investigations of Oscillating Flow over Sills: Generation of Internal Tides and Solitary Waves

Final Report to the Office of Naval Research

December 20, 2006

PROJECT INFORMATION

Award Number: N00014-04-1-0430

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Project period: 05/01/2004 to 09/30/2006

LONG-TERM GOALS

The goal of this project is to identify processes relevant to the generation, propagation and dissipation of finite-amplitude internal solitary waves observed in the region from the Luzon Strait to the Chinese continental shelf.

OBJECTIVES

The objectives are 1) to demonstrate the feasibility of studying finite-amplitude internal waves using a nonhydrostatic model, 2) to describe the generation and propagation of nonlinear internal waves in the northern South China Sea in idealized settings, and 3) to provide information on wave characteristics to principal investigators in ONR's Nonlinear Internal Waves Initiative (NLIWI) for planning of field experiments.

APPROACH

Processes of wave generation, propagation and dissipation were studied under different scenarios of bottom topography and stratification, using a nonhydrostatic numerical model. Experiments included wave generation at ridges in the Luzon Strait and wave propagation across the deep basin.

WORK COMPLETED

A nonhydrostatic numerical model was successfully developed for the study of large-amplitude, nonlinear, internal solitary waves. The nonhydrostatic model proved to be robust. The development used the object-oriented programming technique in both Matlab and C++. A paper summarizing this novel approach has been published (Shaw and Chao, 2006).

Studies completed include (1) the generation of internal solitary waves from a ridge by tidal currents and from a sharp Kuroshio front, (2) the propagation of waves in an ocean with a shoaling thermocline, (3) generation of mode-2 waves, (4) wave reflection and diffraction from a circular island like

Dongsha, and (5) wave transmission in a two-ridge system. A paper describing how a circular island reflects and diffracts solitary waves is in press (Chao et al., 2006a). A manuscript describing the ridge effects on waves has been submitted (Chao et al., 2006b).

PUBLICATIONS

P.-T. Shaw and S.-Y. Chao (2006) A nonhydrostatic primitive-equation model for studying small-scale processes: an object-oriented approach. Continental Shelf Research 26, 1416-1432. [published, refereed]

S.-Y. Chao, P.-T. Shaw, M.-K. Hsu, and Y-J Yang (2006a) Reflection and diffraction of internal solitary waves by a circular island, Journal of Oceanography. [In press, refereed]

S.-Y. Chao, D.-S. Ko, R.-C. Lien and P.-T. Shaw (2006b) Assessing the west ridge of Luzon Strait as an internal wave mediator, Journal of Oceanography. [Submitted, refereed]

REPORTS

Annual reports to ONR: 2004, 2005 and 2006.

STUDENT INVOLVEMENT

Code development in C++:

Ping-Feng Chen, summer 2004, graduate student in Computer Science Department
Ping-Lin Hsiao, Nov 2004-August 2005, graduate student in Computer Science Department

Internal solitary wave simulation:

Alyssa Hopkins, spring 2005, undergraduate student, Department of Marine, Earth, and Atmospheric Sciences
Aaron Rose, spring 2006, undergraduate student, Department of Marine, Earth, and Atmospheric Sciences
Yen-Ting Hwang, summer 2006, visiting undergraduate student from Taiwan